1

EXPERIMENTAL RESEARCHES

UPON

TUBERCULOSIS AND SCROFULA.

BY

EDWIN WOOTON,

AUTHOR OF "THE PHYSIOLOGY OF NIGHTMARE," "THE CENTRALISATION OF ENERGY," "MIMOSIS INQUIETA," AND OTHER RESEARCHES.

Reprinted from the Dublin Journal of Medical Science.

DUBLIN:
PRINTED FOR THE AUTHOR
BY JOHN FALCONER, 53 UPPER SACKVILLE-STREET.

1886.

EXPERIMENTAL RESEARCHES

UPON

TUBERCULOSIS AND SCROFULA.

INTO the consideration of the common phenomena of Tuberculosis and Scrofula I need not enter—they are or should be known to every medical man and student.

To determine, if possible, the nature and ætiology of these diseases I, when a clinical student, made such observations as lay within the scope of my practice—not studying here a little and there a little, but selecting particular because promising cases, and following them from the earliest opportunity until the incidence of recovery or death.

The conclusions, however, at which I was enabled to arrive were unsatisfactory, because in the human subject I could submit them to no real test whether within or outside the hospital. It is true that theories could be formed, deductions made, and inductions followed, but the data were not in themselves sufficiently assured to permit of perfect reliance being placed on any course of reasoning based thereon.

Impressed with these convictions I, some time since, began the study of experimental phenomena in the brute world in relation with tuberculosis and other major diseases, and have continued it until the time of writing. It is a pursuit full of difficulties—legal, social, and scientific. The investigator is hampered by absurd anti-vivisection laws, to evade and defy which is his simple duty; and he is annoyed by the sentimentalism of weak-minded neighbours or acquaintances who may become aware that he is engaged in research, and who regard him as a nineteenth century "six hundred threescore and six." These are all, perhaps, of which he

has a right to complain. Difficulties purely scientific in their character he must expect to encounter at every step of his journey; and they exist but to be taken prisoners and made to reveal the secrets of Nature's kingdom.

I have thought it well to place the results of my investigations in the form of question and answer. Each question is as I propounded it before commencing the experiment or experiments having reference to it. This plan will enable the reader to refer in a moment to any point he may wish to consider. The summing-up has been written in the ordinary manner to form an unbroken chain of argument.

The microscopic powers used in the following experiments were the $\frac{1}{8}$, $\frac{1}{10}$, and $\frac{1}{16}$ inch. The antiseptics were hydrogen peroxide, pure glycerine, carbolic acid, and permanganate of potassium, these three last being placed with one, forty, and sixteen parts of distilled water respectively.

I wish to point out that stained specimens of septic fluids and tissues are not to be depended on as exhibiting the forms to be found in the fresh state. The process of washing after staining, which has to be performed in order to get rid of excess of dye, removes also many of the forms. All observations conducted by means of such stained and washed specimens, if unsupported by evidence based on the examination of fresh materials, must be considered as fallacious.

With regard to the means used for inoculating animals, I find nothing simpler or better than the following:—Take a piece of ordinary glass tubing, about five centimetres in diameter and one decimetre in length; bring one end of this to a fine point by heating; with a piece of iron wire, some cotton wool and fine silk, a piston can easily be made; when this is inserted into the tube the experimentist has, at a nominal cost, an injector which can be used both for the tissues and vessels. The cheapness of the materials enables the economical worker to have three or four dozen of the instruments on hand. When once used they can be taken to pieces, the cotton wool burnt, and the glass and wire subjected to a red heat before being again made serviceable. To inject materials by blowing them out of a glass pipette is to invite failure, where the presence in the fluid of a living form from the mucous membrane of the mouth would negative the value of the experiment; and no such researches carried out by this means can be for one moment considered as reliable.

I. TUBERCULOSIS.

Question 1.—Does pus from tuberculous organs exhibit any independent forms of life?—In pulmonary pus recently coughed up no forms of life are detectable, if it be not fœtid. If kept, it undergoes the same septic changes as other animal matters. Pus taken from mesenteric ulcerations is, under similar conditions, also lifeless. But when abscesses exist, having a communication with the atmosphere, through the bronchi or intestines, the pus is frequently retained for some time after formation, and will then be found swarming with septic matters. In all such cases the pus is fœtid. The nature of the forms found is dependent on the length of time during which the pus has been exposed to atmospheric influence. They consist, when at its highest state of development, of micrococci, microbacteria, desmobacteria, vibriones, and spirobacteria. I use these terms because they are generally understood, but I am by no means satisfied with the ordinary classification of the bacteria.

Question 2.—Do these forms undergo any change when the pus has been taken from the body?—Yes; but the nature of these changes will depend on the conditions. If the pus, whatever its state of septicism, is placed in a closely-sealed bottle, and kept for some weeks, it will be found rich in the living forms already mentioned. These are continually perishing and giving origin to fresh generations. In closed bottles there is no development above bacteria. If, on the other hand, the pus, either in sufficient quantity to prevent complete evaporation, or mixed with distilled water, be kept in an uncorked bottle, in the open air, true infusoria will, in the space of a few days, make their appearance.

Question 3.—Is there detectable by the microscope, in tubercular pus, any form of life peculiar to itself?—No. The forms are those found in all septic matters, and present no peculiarities.

Question 4.—What are the septic phenomena and conditions of tubercle itself?—Merely those of other animal matters.

Question 5.—Does the blood of tuberculous animals exhibit any microscopic peculiarity?—There is always an excess of white, and a diminished number of red corpuscles.

Question 6.—Are septic matters to be found in the blood?—They are to be seen when there exists in the animal a purulent tissue exposed to the influence of the atmosphere, and only in such case.

Question 7.—Are the contents of any particular classes of blood-vessels more especially affected?—Kill the animal by piercing the brain. Open the thorax, place a ligature round the roots of the lungs, and another round the aorta. A portion of the contents of the vessels can then be drawn off with a hypodermic syringe. The septic matters will be found chiefly in the small veins proceeding from the part; next in the smallest arterioles, and to a very limited extent throughout the larger vessels.

Question 8.—Are they to be found in the lymphatics?—The lymphatic vessels should be dissected out in their passage along the bronchi and ligatured with silk, at short intervals. Septic matters will be found in abundance in the vessels near the part affected, diminishing in relative number with their distance from this part. Traces can also be detected in the fluid expressed from the bronchial glands in connection with the lymphatics concerned.

Question 9.—What forms of life are these?—Micrococci, micro-bacteria, and bacilli, throughout the vascular and lymphatic systems. Vibriones and spirobacteria may occasionally be seen in the small vessels, adjacent to the putrescence. They are not to be found in the large veins, arteries or lymphatic trunks. Torulæ are altogether absent.

Question 10.—Do these bacteria multiply within the blood and lymph?—In tubercular and pneumonic phthisis, when the septic condition has become established, and antiseptics, as vaporised carbolic acid solution, are employed by inhalation to prevent germination in the pulmonary tissues, the bacteria found in the blood and lymph diminish in number in proportion to the stringency of the antiseptic conditions; and if the last be maintained thoroughly, for even a few hours, the septic matters altogether disappear. That this is not due to an antiseptic condition of the blood and lymph, is shown by the fact that if in any such animal a wound be made in one of the extremities, and rendered putrescent by continued irritation, the living forms mentioned occur in the vascular and lymphatic systems, although antiseptics are used for the pulmonary lesion. They are most numerous at the point of lesion, in the same manner as when the lung is concerned.

The presence of septic matters in the blood and lymph is due to their constant reception under putrescence of the tissues.

Question 11.—What are the blood and local-tissue peculiarities of hectic fever?—Those always occurring, in a more or less marked degree, when a putrescent lesion has been established.

Question 12.—Can hectic fever be induced ?—If any highly vascular organ, as the lung, kidney or testicle, be wounded and allowed to become putrescent, by being kept open and irritated, from time to time, with a blunt, pointed instrument, a fever follows, undistinguishable from that known as " hectic."

Question 13.—What effects follow the application of antiseptics to the putrescent surface ?—The antiseptics should be applied by external dressings and direct inspection—in the case of the lungs by inhalation also. The first observable result in the living animal, after the expiration of some thirty minutes, is an abatement in the intensity of the febrile symptoms. If the animal be now killed, the septic bodies will be found in comparatively insignificant numbers, both in the tissues and blood and lymph vessels.

Question 14.—Has the blood of hectic animals infectious properties ?—If drawn from the seat of the morbid processes, and injected into blood-vessels of another animal, symptoms of hectic result, but these pass off rapidly, unless the wound made by injection itself become putrescent. If the blood be taken from a vessel far distant from the lesion, no morbid results will follow its injection.

Question 15.—Has tubercle or tubercular pus any infectious properties ?—If these matters are placed in cotton wool, being well worked into its substance, and this is passed as a respirator over an animal's mouth, negative results follow. If the lung be first wounded, and the respirator applied when, or kept on until the tubercular matter is putrescent, hectic and exudation ensue.[a]

Question 16.—Of what character is the exuded material, and in what part of the lung is it found ?—It is of an almost watery consistence, colourless, and is found in the neighbourhood of the wound, diminishing in an outwardly increasing circle. It resembles exactly the fluid that can be expressed from the ordinary caseous tubercle, found in the human subject, and, like the latter, contains leucocytes.

Question 17.—What effect is produced on the lungs by the respirator, if the blood-vessels be ruptured by coughing ?—If irritants, as fine snuff or pepper, be passed through a tube, into the animal's lungs, until the rupture of one or more vessels is indicated by the blood coughed up—septic and inflammatory results follow. The severity of these processes will depend on the extent of the lesion.

[a] The exudation is altogether more marked than that resulting from a wound only.

Question 18.—Can tubercle of any organ be brought about by direct local inoculation?—Non-putrescent tubercular matter, injected into a small trochar wound in the lung or kidney, does not occasion any symptoms beyond those of common inflammation. Neither does the injection of pus. If putrescent, either will cause violent septic symptoms, and the formation of abscesses in various organs, notably the spleen. The fluid-deposit mentioned is always present in one or more organs, and in some cases may be found infiltrating large areas of tissue.

Question 19.—Do the same symptoms follow the injection of septic matters, not tuberculous?—Yes; certain animal matters, as urine, and muscle and blood serum. Vegetable infusions and juices, unless they are, in the first place, poisonous, are not productive of such severe results.

Question 20.—What results follow the injection of tubercular matter from a human subject into the blood of a quadruped?—If non-putrescent, only negative results ensue. If putrescent, only the symptoms following the injection of other septics.

Question 21.—What results follow the injection of putrescent tubercular matter into lymphatics?—Non-septic miliary and caseous tubercle give negative results. Putrescent miliary tubercle gives rise chiefly to septic and pyæmic symptoms and swelling of lymphatics. Exactly the same results follow the use of other septics. Putrescent caseous tubercle, and the liquid expressed from it, occasion great swelling of lymphatics and a fluid deposit in one or more organs. In one case, where half a drachm by weight of the caseous material was injected into the thoracic duct of a kitten, there ensued, besides the pyæmia, great splenic inflammation and a deposition of fluid in the mesenteric glands, the lungs, and the kidneys.

Question 22.—Will any other septic matters give this result?—Yes, all; and even non-septic irritants as powdered iron in water, but not to the same extent. There are only two septic matters other than caseous tubercle I have found equal it in intensity of effect, and these are—the expressed fluid from this tubercle and putrescent lymph.

Question 23.—Will this putrescent lymph affect the lungs through the respirator?—Yes, in the same manner as other animal septics.

Question 24.—Can the formation of tubercle be shown under the microscope? Yes, and in the following manner:—First, kill a frog; open the abdomen, and inject the large lymphatic vessels, proceeding

upwards from one of the hind legs, with pigment, after drawing off the lymph. This will give an accurate notion of the anatomy of the lymphatics, as they can on dissection be easily seen, and the preparation will serve as a model. Now, take another frog, and sever the lymphatics of the leg about the middle of the femur. Tie both extremities as cut; dress the wound, and place the animal in as easy a position as possible, with its foot under the microscope. Be careful not to irritate the foot. The frog, if it does not prove altogether unreasonable and die, may be kept in this position for some days, being fed with gnats, flies and other such luxuries.

Nothing abnormal will be observable at first, but after a few hours the lymphatics will be seen to enlarge, and the lymph spaces to be filling with a semi-opaque material. Then the capillaries diminish in calibre, due to the pressure on their walls of the newly-seen material. If the frog be killed at this stage, and the foot dissected, the material previously seen under the microscope will be found to resemble common miliary tubercle, but it has no stroma. If the experiment be performed again, it will be found that after the formation of tubercle has been well established, the small blood-vessels appear irritated and exude—first, leucocytes, and next, serum, as in ordinary inflammation. Any uncut lymphatics are similarly affected.

The immediate result is cell proliferation in and about the tubercle, resulting in the formation of a stroma. If now the frog be removed, and every means taken to allay the inflammation, we shall find, on dissection, a perfect example of stromad miliary tubercle. The experiment may be repeated the third time, to show the effect on this tubercle of the lympho-vascular inflammation. Briefly, it results in the softening of the mass, which softening, if the blood-vessels are completely occluded by the inflammatory processes, may become purulent.[a]

An interesting physiological fact may now be noticed. If the lymphatics of the leg be cut and tied as before, and inflammation brought about by irritation, the exuded fluid will, when such irritation has ceased, lessen in quantity, while the capillaries and small veins enlarge. At the same time the leucocytes, for the major part, appear to undergo disintegration, while some few pass

[a] The statement put forward by a Dr. Alabone that tubercular matter is at the first albuminous, is, I have found, utterly erroneous. Tubercular matter never gives the reaction of albumen. Its albuminoid constituents do not, from the commencement, reach a higher percentage than those found in lymph.

into the interior of the blood-vessels. There is, then, a re-absorption by the blood-vessels, which, to some extent, act vicariously for the lymphatics.

Question 25.—What morbid results follow the injection of the freshly-drawn blood of a tuberculous animal, in whom no septic symptoms exist, into the veins of another?—The only important result in the animal receiving the blood is its apparent strengthening. I have used from half an ounce to two ounces without any other effect, save the phenomena always following increased blood-pressure.

Neither tubereulous nor any other morbid symptoms made their appearance in any of the animals I had an opportunity of keeping under observation, and on killing them at the expiration of six months from the date of the experiments, the lungs were found perfectly healthy.

Question 26.—Can tuberculosis be induced by mechanically irritating any organ or part of the body?—In the case of the lungs, a cotton wool respirator should be employed, its meshes being filled with irritant powders, as steel and coal-dust. The process must be very carefully carried on, the respirator being removed at the slightest sign of acute inflammation, and for a time discontinued. It should be worn by the animal at all times, save for about ten minutes twice daily, a period sufficient for it, in which to take its food. The condition can be developed in other parts by prolonged irritation of the lymphatic glands, as by piereing them daily with a fine needle, or passing through them a seton of silk.

Question 27.—What is the immediate local result of such irritation?—First, enlargement of the lymphatic glands. The blood-vessels entering them are engorged, and the channels in the gland tissue are nearly occluded with a mass of sluggishly-moving lymph corpuscles. Next, the lymphatics on the proximal side of the glands become congested; and lastly, the lymph exudes into the surrounding tissues.

Question 28.—What is the character of this lymph?—It is undistinguishable from that found inside the vessels, and closely resembles the fluid that may be expressed from caseous tubercle. The latter, however, is rather more opaque, due to containing cellular *débris*. This cellular matter can be removed by filtration under atmospheric pressure, and the fluids are then undistinguishable from each other. *There exists, in fact, a condition hitherto unrecognised—a true lymphatic inflammation. Side by side with this, vascular inflammation may obtain.*

Question 29.—How can lymphatic inflammation be shown during life?—Fasten a frog under the microscope, as when the phenomena of common vascular inflammation are to be viewed. Sever the blood-vessels in the animal's thigh, carefully ligaturing the proximal extremity of each. Leave the nerves, as far as can be, intact. Then insert the needle of a hypodermic syringe into the cut mouth of each open vessel in turn and draw out the contained blood. Next, inject the veins and arteries with pigment. If now the frog's foot be irritated with a needle, the lymph containing the corpuscles will be seen passing from the lymphatic vessels into the surrounding tissues.

Question 30.—Are the intestinal secretions acid in tuberculosis?—No. If an animal, as a cat, in whom general tuberculosis has been set up, be killed, the intestines cut open, washed and then scraped, the material collected is generally neutral, and not infrequently alkalial. If such an animal be kept without food for some days, and the intestinal contents gathered by scraping only, they are but slightly acid. This acidity is due to the bile; for if the bile ducts be tied and the animal kept without food for twenty-four hours the intestinal contents are invariably neutral. The ordinary intestinal contents of any tuberculous animal kept on its usual dietary are always acid. The acidity is marked in carnivora, as cats, and but slight in the vegetable-feeding rodents. In the carnivora the acidity is in direct proportion to the amount of fat eaten. It is due to the fatty matters of the food being in great part unabsorbed and split up into fatty acids.

Question 31.—Is there more or less bile in tuberculosis?—If the common bile duct of a cat be tied, the gall bladder opened and the edges of the incision stitched to those of the external wound, the quantity of bile secreted can be readily estimated. There is always a lessened amount in general tuberculosis. For whereas in health a full-grown cat will have from three to five ounces sent daily into the intestine, with the establishment of the tubercular condition this amount lessens, and that progressively until in many cases only about half an ounce is formed. But if a large extent of lung-tissue be destroyed, the amount of bile will increase, owing to the vicarious action of the liver in excreting carbon.

Question 32.—Is there more or less pancreatic secretion in tuberculosis than in health?—Less, but the diminution in quantity is comparatively not so marked as in the case of the bile. The question is determined in a manner similar to that relating to the bile: the duct of the pancreas being tied, and cut between the ligature

and the gland, the open end of the untied portion is then stitched to the edges of the outer wound, establishing a fistula.

Question 33.—Can pneumonic pulmonary phthisis be brought about in a healthy animal by thermal changes alone?—Yes, if the surface of the thorax be suddenly and severely chilled when hot, and particularly when the heart's action is strong; or if the chest, under any circumstances, be exposed to intense cold, the lung capillaries become engorged, and inflammation, followed by various secondary processes, as the blocking of the bronchi through mucous clots, and consequent collapse of pulmonary cells, will result if the morbid processes are not subdued. But in all cases the exuded material, by pressing on the blood-vessels, cuts off the vascular supply, and the resulting innutrition of the tissues terminates in their disintegration—phthisis. Moisture has no influence whatever other than thermal.

Question 34.—Does lymphatic inflammation play any part in these pathological processes?—It does, but secondarily; for thermal changes do not readily affect the lymphatics. The exuded vascular material, however, itself acts as an irritant to the lymph vessels, resulting in the passage through the walls of their contents.

Question 35.—Can miliary tubercle result in a previously healthy animal under this condition?—If pulmonary inflammation be set up in a number of animals, as kittens, and allowed to proceed, and the animals killed at various stages of the disease, the lympho-vascular fluid will be found to become more dense in proportion to the time the inflammatory condition has been established. At the last it is of a creamy consistence and contains granular *débris;* but surrounding and pressing on the interstitial spaces in which these pathological changes are to be seen, in places where the blood supply has not been cut off, there will be found a material altogether foreign to that which has been exuded, and which is evidently nothing but the unabsorbed cellular *débris* of the normal tissue. In cases where the inflammation has been allowed to run on for some time, and absorption then brought until the disappearance of every inflammatory sign, these areas of *débris* accumulation are plainly observable, the fluid being absent. They are, in fact, nothing but masses of miliary tubercle. If such an inflammation be induced, and subdued and again induced, the miliary tubercle will be seen mingled with exuded fluid, under whose influence in various stages the tubercle is becoming softened.

If the inflammation be subdued and the animal kept for some

days under circumstances which preclude the possibility of there being any extra-corporeal exciting causes of the inflammatory state, there will be found scattered masses of miliary tubercle, and the number and size of these tuberculous loci decreases in proportion to the time the animal has been kept alive subsequent to the subdual of the inflammation.

Question 36.—Can miliary tubercle be brought about without any previous exudation?—Yes; if cats be kept in a condition of semi-starvation for from three to five weeks, and in the interim the lymphatic system is exhausted, as it easily can be by the administration of iodine—if by inunction, $4\frac{1}{2}$ grs.; if by inhalation, $1\frac{1}{2}$ grs.; and if internally, $\frac{1}{2}$ gr. respectively, five times daily, the lungs, kidneys, and sometimes other organs will show variously-sized patches of tubercle.

The food should be comparatively dry. In the case of cats, one ounce of broken biscuit with half an ounce of water may be given daily.

Animals merely starved to death do not exhibit these *post-mortem* signs.

The condition, however, may be rapidly brought about by complete starvation and the administration of iodine in excessive but not acutely poisonous doses.

When the iodine is given internally the mesentery is more especially affected; when by inhalation, the lungs. Inunction on the thorax and abdomen affects the organs mentioned situated in these respective parts. Inunction on the extremities results in general tuberculosis of a less marked character.

Question 37.—In chronic cases of inflammatory phthisis before the formation of tubercle, are the powers of secretion and absorption impaired?—Yes; there is lessened bile and pancreatic secretion, and decreased absorption.

Question 38.—In cases where pulmonary tuberculosis has been induced through thermal conditions, is tubercular matter to be found in other organs?—It is detectable only when the pulmonary condition has been very chronic and the system altogether enfeebled. Then also it is very easily induced by exposing the body to heat and cold alternately.

Question 39.—Is tuberculosis hereditary?—If local tuberculosis be induced in an animal, tubercular complaints are more easily developed in its young born after the incidence of the disease in the parent, than in other animals derived from a healthy stock. More

especially is this the case if there has been general lymphatic irritation induced mechanically or by injection of septic matters into lymph vessels.

If the tuberculous condition be brought about in the young mentioned when of sufficient age to breed, their own offspring will, under exciting conditions, pass more readily into the tuberculous state than they themselves. It is, of course, understood that all three generations have brought to bear on them the same influences.

Question 40.—What follows the contact of tubercular matter with an open wound in the extremities?—If not septic nothing whatever ensues. If septic the immediate result is very circumscribed vasculo-lymphatic inflammation. Then the lymphatic glands and larger vessels become congested, and there is extensive lymphatic exudation. This spread of the lymphatic inflammation always precedes that which is purely vascular. The latter, indeed, very frequently does not take place; should it do so the condition known as erysipelas is established. If the septic conditions be maintained pyæmia follows. From no such wound have I ever seen general tuberculosis ensue. In fact, the limb perishes from gangrene or sloughing before anything approaching such a result is obtained. At the same time such animals are more readily affected with general tuberculosis under exciting conditions than others.

The results given follow, to some extent, the contact of all septic matters, but there appears to be a more powerful influence exerted on the lymphatics by putrescent lymph or tubercular matter than by other septics.

If the wound be in the neighbourhood of a lymphatic gland of any size, and be cleaned daily, but the septic condition kept up to induce a state of chronic inflammation, there results general lymphatic irritation, together with lymphatic inflammation in distant organs.

Question 41.—Has miliary tubercle always the same structure?—No; at first it does not show any proper stroma at all. The latter develops with the age of the nodules, and is sometimes, even in old cases, almost absent. It is undoubtedly a growth due to leucocytic metamorphosis. In many spots of tubercle the leucocytes can be seen in the line of the stroma—some normal, others throwing out branched processes. They extend their way between the cells of the tubercle, and unite, losing their distinguishing characters, until they form a network of apparently structureless tissue.

Question 42.—In what organs of the animal's body is tubercular

matter, as commonly understood, found?—In the peritoneum, lungs, pia mater and the arteries in connection therewith, spleen, liver, and kidneys.

Question 43.—Is any other kind of heterogeneous matter to be observed in other organs?—Yes; specks and nodules of abnormal structure are frequently to be found in the pericardium, or the membrane covering the valves of the heart, and in the walls of the bladder.

Question 44.—Have the organs and parts commonly affected with tuberculosis any structural points in common?—They are all highly vascular, and largely supplied with lymphatics. Where not actually serous membranes they are intimately connected with such. They are, moreover, membranous to a greater or less extent—that is, they are either composed of membrane or have continued into their interior, membranous processes derived from the external investing layer, and which is in intimate connection with the serous covering.

Question 45.—Apart from tubercle itself and vasculo-lymphatic inflammation, has the tuberculous condition any general effect on the tissues?—Yes; there is a degenerative atrophy throughout the whole body, the tissue cells being weak, and the structure into which they enter lessened in bulk and atonic.

Such are the experiments I have performed to elucidate, if possible, the nature of this dread condition, and such are the results I have obtained. Let us now briefly reconsider the main questions at issue, the evidence relating thereto, and the conclusions to which this points.

Tuberculosis is the name applied to a condition which we have found has invariably two factors—vasculo-lymphatic exudation, and non-removal of effete cellular material. The vascular process is commonly termed inflammation; there is also an inflammation truly lymphatic in its nature.

Tuberculosis may commence in one of two ways—either by peripheral irritation, as under certain thermal conditions; the inhalation of dust, &c., in which case the first step is exudation, and the second, through the occlusion of the lymphatics, the non-removal of effete tissue; or by inactivity of the lymphatic system when the exudation follows as a secondary process.

This secondary process is a vasculo-lymphatic inflammation caused by the irritation set up by the non-removal of cellular material.

This tissue *débris* forms miliary tubercle. The stroma is produced

by the proliferation of exuded leucocytes and lymph corpuscles. The metamorphosis of the miliary into caseous tubercle is due to softening under the influence of the exudation. A vasculo-lymphatic exudation and the non-removal of cellular *débris* may occur in any part of the body, the peculiar appearance of the commonly-termed miliary tubercle being due probably to the character of the tissue concerned.

Tuberculosis affects certain organs and structures more readily than others—these are the peritoneum, lungs, pia mater and the vessels in connection therewith, kidneys, spleen, and testicles; and it is in these alone that I had ever found miliary tubercle.

Tuberculosis is essentially a lymphatic disease. There is lessened power of absorption throughout the system. Fatty matters are not taken up by the intestinal vessels as in health. but are for the major part split up into fatty acids,[a] and this results in lessened bile secretion, which in its turn causes increased impoverishment of the system through the non-emulsifying of solid fat eaten. When any extent of lung tissue is destroyed, the amount of bile is increased, and necessarily, chiefly at the expense of elements which, excepting the carbon, are required in the system.

As the morbid condition progresses the other secretions lessen, among them being the pancreatic fluid; and this, impairing as it does still further the process of saponification of fat, still further lessens its absorption.

In tuberculosis the lymphatic glands are weak, liable to congestion, and do not elaborate the white corpuscles. As a result, the blood is filled with a number of immature white cells, which are not elaborated into red corpuscles.

Inflammation can never occur without involving the lymphatics, and in all inflammation the white corpuscles of the blood are increased and the red lessened in number.

Any prolonged or severe irritation to the lymphatics may bring about tuberculosis, throw the glands and nerves supplying them into disorder, as indicated by pain and swelling—in fact, result in lymphatic inflammation. An example of this last is to be seen in cellulitis.

[a] Fat does not normally split up into glycerine and fatty acids until acted on by the pancreatic secretion, when saponification *immediately* takes place. In the abnormal chemical disintegration of fat the acids themselves decompose after liberation. In such case they are in great part wasted. The saponified fats also, when not absorbed, break up, and it is to this action the peculiar acidity of the intestinal contents in tuberculosis is chiefly due.

Whenever a part exposed to the atmosphere has broken down, vivification of germs takes place; these multiply at the point of lesion only, passing thence into the blood. There is not any form of life detectable by the microscope peculiar to tubercular blood, pus, lymph, lymphatic exuded fluid, or serum.

The influence exerted by septic matters from any tuberculous animal, when injected into the body of another, is the same in kind as that appertaining to a variety of septics not tuberculous. At the same time putrescent matters derived from the lymphatics are more powerful in action than any other septics.

It is probable that this is due to some affinity between the non-septic lymph and its septic derivatives. This increased influence, however, is seen only when the matters are injected into the lymphatics, or have other ready access thereto. In the blood their intensity of action does not differ from that of many other septics.

The hectic fever of phthisis is due altogether to the development of living forms in the lung tissue. It may be prevented and cured by the use of antiseptics, and may be induced by injecting into the blood-vessels or lymphatics any septic matters.

Quitting now the direct results of my experimental work, let us briefly consider some of the more prominent pathological facts and questions, other than those dealt with, having relation to the condition of pulmonary tuberculosis. When death occurs as a result of pulmonary phthisis, it is due to atony of the whole system—the vital functions of all the organs being too weak to maintain the body's life. This atony is in itself a direct result of innutrition. The innutrition results from impoverished blood. This vascular impoverishment has three factors—(1) faulty digestion, as seen; (2) constant discharge of blood materials in the form of pus or mucus, or both, which contain a large proportion of inorganic salts and animal matters; and (3) lessened oxidation.

Delicate people, not phthisical, are more readily affected with pneumonic phthisis than those who are in robust health. This increased liability must be ascribed to weakness of the structures taking part primarily in the disease—the blood and lymph vessels. Such weakness is, according to physiological law, the result of innutrition.

The tendency to tuberculosis is frequently inherited—such congenital tendency must be due to weakness of the lung lymphatics, in its turn resulting from their innutrition. The lymph and blood-vessels, like all other tissues, derive their energy when once built

from the energy-conveying machine—the nervous system. The value of this pathological knowledge will be evident when we speak of the therapeutical treatment of tuberculosis.

One question I have had much at heart, but have not been able hitherto to determine—my experiments in connection therewith giving no satisfactory result—Is there a lymphatic nervous centre?

Pulmonary tuberculosis is the inseparable accompaniment of pulmonary consumption. In certain cases it is the proximate precursor of phthisis; in others, it is merely secondary to a pneumonic process.

With the experimental therapeutics of tuberculosis I shall deal, in connection with that of scrofula, when the latter condition has been considered.

II. SCROFULA.

VERY generally the two pathological terms heading this paper are used as indicating but two different degrees of one condition. It has been often laid down as a medical axiom that scrofula is merely a coarse form of tuberculosis, and it is the common acquiescence in this scientific heresy which has rendered the treatment of the diseases a matter of empiricism, for the existence of such an axiom predicates the grossest ignorance as to their pathology.

Surprise is naturally felt that the *primâ facie* differences in the external phenomena exhibited by the two conditions did not indicate to the earlier observers that there were intrinsically different pathological processes at work in their production. To describe scrofula as but a coarser form of tuberculosis means, if anything, that the pathology of the two states is identical in kind but different in degree.

The opinion to which I have alluded, although broadly fallacious, contains fragmentary truth. It must have come within the range of the earlier pathologists—for no fact is more evident—that in tuberculosis and scrofula there is an unusual liability to enlargement of the lymphatic glands. Not knowing why in each division such enlargement occurred, and observing that in the coarser disease suppuration more frequently took place, medical scientists ascribed the differences to the varying intensity of unknown processes identical in kind. It is my belief, which I state with all due modesty, that by my experimental work I have wrested the knowledge of the true pathology of scrofula from Nature and placed it plainly and demonstrably before the world. Other and more detailed truths in connection with the disease undoubtedly remain to be discovered, and this task, almost impossible of accom-

plishment while the direction in which experimentalists should labour was unknown, has now become practicable.

The first point which engaged my attention in connection with scrofula was its possible septic origin. As in the previous article, I shall place the record of my experimental work in the form of question and answer :—

Question 1.—Is there to be found in scrofulous abscesses, or elsewhere in scrofulous patients, any form of life peculiar to the condition ?—No. Forms peculiar to scrofula are unknown. The tissues may of course be septic, when bacteria will be found.

Question 2.—Have these any specific influence ?—No. They possess merely that of common septic matters. Scrofula is not produced by their injection into the blood, nor if they be placed in lymphatic trunks or glands. Under these circumstances the results brought about are those we have seen to follow the injection of tubercular matter.

Question 3.—Is there any difference in the virulence of the septic poison, having relation to the parts whence it is taken ?—Yes. Septic pus from suppurating lymphatic glands of a brute has a far more powerful action when injected into the lymphatic system of another animal than when taken from any other part.

Question 4.—What follows the injection of such pus ?—The phenomena of tuberculosis previously described.

Question 5.—Is scrofula communicated by any such experiment ?—No. None of the phenomena characteristic of scrofula follow. The conditions brought about are distinctly tuberculous.

Question 6.—Can scrofula be communicated by any other means ?—It cannot by simple transfusion of blood, although the animal receiving the scrofulous blood suffers for from twenty-four to seventy-two hours from general malaise. Transfusions performed once in three days on six consecutive occasions, will, if the quantity of blood used be sufficiently large, produce scrofulous symptoms. The quantity transfused should equal two-thirds of the whole normal amount in the animal injected. It is necessary to bleed the receiving animal until coma is produced before transfusing, and while the transfusion is in progress to permit the blood to continue running until the estimated quantity has been drawn. The scrofulous animal from which the blood is taken is, of course, sacrificed unless steps are taken while the transfusion is in progress to inject into its vascular system either blood or an artificial fluid. Scrofula can also be induced by exhausting processes, but not in

the first generation, that is, in the first animal subjected to experiment. By giving a male guinea pig aphrodisiacs to ensure repeated copulation, and at the same time a lessened supply of food—about two-thirds its ordinary allowance, the following symptoms occur: alopecia, ptyriasis, flaccidity of the sclerotic and cornea, photophobia, and occasionally varix. If nerve foods, such as the phosphates, phosphoric acid, &c., be employed, in combination with the application of electricity to the spinal column, these symptoms do not result. The influence of a vegetable dietary appears to be of paramount importance, for in strictly herbivorous animals, as those of the class mentioned, a far longer course of exhausting treatment is required to produce the phenomena specified than in the omnivorous rat. In the case of this latter animal I have found the usual number of days required to be eleven when kept on meat diet; in the former never less than twenty-one. Individual cases from each class of animal differ very widely, but the relative differences between the herbivora and omnivora is retained. When the rats were kept on a vegetable dietary their susceptibility to the exhausting processes was lessened. In some cases their power of resistance equalled that of the guinea pig. The explanation is probably to be found in the fact that unlike compounds more readily combine with each other than do like. The result of the experiments to the meat-gorging public is of significance.

Question 7.—When these phenomena have been brought about, is there any peculiarity in the blood?—Yes; there is a diminished number of red blood cells, and the majority of them appear undeveloped, with ill-defined form and lessened colour.

Question 8.—When the condition described as being produced by exhausting processes obtains in the male of a breeding couple, what will be the physique of their young, born after the incidence of such condition?—As a rule there is no structural disease detectable, either in life or *post mortem*, if the animals be killed. There is, however, a general physical deterioration rendering them liable to contract disease under slight influences.

Question 9.—What will be the effect on the young males of subjecting them to the same conditions as was the male parent? and what will be the effect on their own offspring?—The phenomena observable in the first generation will be intensified; the veins will tend to become varicose, the arteries to rupture, forming aneurysms, the capillaries to distend at any point of strain, as about joints. From this last, as well as from chronic inflamma-

tion, to which the capillaries are very liable, there frequently ensues hyperplasia, which in many instances becomes ossified. In the offspring, that is, in the third generation, I have frequently seen congenital disease of the skin, capillaries, and lymph glands. When not actually congenital such disease ensues from the most trifling irritant causes. The affections of the skin are chiefly alopecia, followed by pityriasis; of the capillaries, inflammation and ecchymosis; of the lymph glands, indurated enlargements, frequently becoming inflamed and suppurating.

Question 10.—Can these results be attained by means other than sexual exhaustion?—Not so readily. They can, however, by subjecting animals to operating circumstances, affording throughout the whole system lowered opportunities of maintaining vitality. Thus, if a male and female of cleanly species, as the wild rabbit, used individually and by their ancestry to breathe pure air and eat wholesome food, be taken from their warren, confined in a foul atmosphere, and fed on unwholesome food, not so poisonous in either case as to destroy life, we shall, after a few weeks, perceive a marked deterioration in their physique. The young of such a couple, subjected to exactly similar conditions as the parents, will very generally have their constitutions adapted to the change, and no marked disease will show itself. But let the circumstances be altered, still maintaining their unhealthy character, as by changing the diet, and the substitution of, say, the vicinity of a foul closet for the interior of a cellar as their place of keeping, and the disease-phenomena we have already noticed will be seen. By breeding under these changed conditions, and the rearing of offspring thereunder, the latter are seen to be physically enfeebled, but not so greatly as the parents.

Actual scrofula is brought about more readily by a continuance of unhealthy conditions under a constant change of character, since the constitutions of the animals have not the time in which to accommodate themselves to these changes, than by unhealthy conditions of uniform character.

Question 11.—What is the condition of the tissues in scrofula, anatomically and chemically?—In the brief space at my disposal it is impossible for me to deal fully with this question. I purpose, therefore, giving the bare outlines of the more important among my rather voluminous notes, and dealing with them in a more detailed manner, in a subsequent article either here or elsewhere.

First, then, it must be understood that there are degrees of

intensity in the scrofulous diathesis. When the condition is fully developed, the external characteristics in the brute resemble those found in the human subject. The joints are enlarged, especially those supporting the body. Attenuation is not general—on the contrary, there is a tendency to the deposition of adipose tissue.

The skin is always affected with pityriasis. In the brute this occurs over the whole body. In the human subject on the face and scalp chiefly. On section the epidermis exhibits a superficial irregularity—many of the cells are broken, others have an ill-defined outline, others again are placed almost edgways to the surface, so that such a section appears not unlike the side view of a cutting through geological strata that have been subjected to a natural upheaval.

Alopecia is very common both in induced and human scrofula. The hair is dry, the individual hairs are found to be brittle, and not infrequently split, or with clubbed tips; loss and irregularity of colour are very frequent but not general. Microscopically, the hair is seen to be roughened on the surface, and the canal is often occluded.

The claws of brutes under experiment, even when the scrofula is congenital, are seldom particularly affected. We shall see the reason of this presently. The nails in the human subject, on the other hand, are invariably involved in the general malnutrition, when scrofula is fully developed. The peculiarities consist in stunted growth, alone or combined with irregular laminæ. The nail presents one or more ridges having the appearance of the slates on the roof of a house. On section the malnutrition is evident, for the appearance presented is that of so many interrupted strata, frequently three or four in the nail's length.

The sclerotic and cornea both in the brute and man are invariably flaccid. There is nothing, microscopically, peculiar in the eye tissues, save that the capillaries are always to some extent congested. This congestion is also found in the lacrymal gland. Irregularity in the position of the teeth is not by any means general, but malformation is frequently to be seen in hereditary cases. This consists of a ridged dentin and irregularity in the length of the enamel fibres. Early decay is pretty constant.

Allusion has been already made to the joints. The enlargement is lateral and due to pressure on the congenital cartilage. Microscopically, this cartilage in the brute shows a flattening of the columnar cells. In the human subject I have not had the oppor-

tunity of examining it. Enlargement of the finger joints is not hereditary in scrofula; it is produced by manual labour or exercise, and is best seen in the working classes. The bones of the arm in the human subject are never bent; in the case of the legs they are very frequently so. This is also, of course, due to pressure.

In the brute affected with congenital scrofula, the limbs are always more or less curved.

Microscopically, there are always to be seen interrupted laminæ towards the external aspect of the bone. They commonly present the appearance of so many semi-circles and arcs united in a series of irregular figures, whilst here and there a nearly complete lamina is to be seen, having enclosed within it one or more of these figures.

The supporting framework of the fat is always attenuated, and the walls of the fat cells are weak, readily yielding under pressure. There is no diminution in quantity save after semi-starvation, but the fat formed is flabby and loose.

To the naked eye there is seldom anything unusual in the appearance of muscular tissue taken either from the scrofulous human or brute subject. But microscopically the case is very different. If the scrofulous diathesis be thoroughly developed, and the muscle from which the section is taken be not one that has been subjected to much healthy exercise, the fibres will be found thinner than they are normally, irregular in length, with ill-developed striæ in the striped muscles. These striæ are in some spots absent. The fibres themselves present here and there no lateral boundary line; while in scattered loci they are of such a diminished length as to resemble elongated cells.

In muscular tissue which has had its growth stimulated by exercise these appearances are absent.

With regard to the structure of the blood-vessels, I have found the muscular fibres affected in the manner mentioned when speaking of muscle. Neither the walls as a whole, nor their individual coats, were throughout the system thickened.

Here and there, in the course of a muscularly-walled vessel, the walls were thinner and the calibre of this part of the vessel enlarged.

Yet, such increased thinness never being seen without the corresponding enlargement in calibre, it would be an unjustifiable assumption to conclude that the latter is the consequence of the former. Rather would the thinness appear to be due to the distension, the

real cause of the yielding being cellular modification, and not alteration in bulk.

The calibre of the skin capillaries in scrofulous brutes and human beings frequently deviates from the normal. The general tendency is in the direction of narrowing; but in places they are distended, while here and there broken down completely. The blood-channel forms a sacculated enlargement, continuous with one or more vessels.

The blood circulation through the capillaries is very generally slow.

The capillaries of internal organs and parts I have not found markedly altered in character.

I have never succeeded in obtaining fresh and unstained sections of the brain and spinal cord from the scrofulous human subject. Such sections alone can give an accurate idea of histological structure. In the brute but little deterioration is apparent. The cells are frequently ill-developed, with, in many instances, fewer branching processes. This is the only change I have up to the time of writing been able to detect.

Cultivation of the brain's cellular structure is, of course, quite outside the range of the laboratory experimentalist's range of research. Thus much, however, I have found to be true—scrofulous children, stupid and dull, increase in intelligence under proper mental stimulation. This intelligence may be of a very high order, and is then invariably associated with what we are justified in considering as external indications of good brain-size and formation.

The stupidity in such cases we must ascribe to cellular faults, not errors in the bulk or design of the brain.

These observations agree with many biographical facts as to the dulness of persons in early life, who afterwards attained great eminence on account of their high mental powers.

It may be said, in conclusion, that scrofula, as induced in the laboratory and as seen in the human subject, present, with the exceptions mentioned, identical pathological appearances.

In considering the morbid anatomy of scrofula, it must be remembered that the tissues are influenced directly by surrounding agents.

Thus, while muscular deterioration is well marked in scrofulous persons leading an inactive life, so far as any particular muscle or set of muscles is concerned, should it be exercised it will follow the common law of physiological growth, and the produced tissue will be healthy in character.

Again, it is, as before remarked, chiefly amongst the working-

classes that we find enlarged finger joints. The same remark applies, though not with equal force, to cases of enlarged joints at the knee and ankle, and to bending of the leg bones. Very many working-people look well after their offspring, and, finding the legs yield, do not permit the child to walk to any extent. The skin and hair again are altogether modified by the treatment they frequently receive from those who study their personal appearance. And the same may be said as to the preservation of the teeth.

It would appear to be in obedience to the common law of stimulation and growth through use that the claws of brutes are less affected by scrofula than the nails of the human being.

The chemical deviations from the normal occurring in the bodily tissues of the scrofulous brute may be summed up as a lessened percentage of mineral constituents and animal compounds, and an increase in the per-centage of water. There is no compound or substance added, and there is nothing absent which is found in the normal state. For details on this very important subject I must refer the reader to a future article.

Question 12.—Are scrofulous animals especially liable to the formation of tubercle?—Yes; the formation of tubercle readily follows any slight irritant conditions, and it speedily subsides when the conditions are withdrawn. It has been in all my observed cases caused proximately by lympho-vascular inflammation.

Scrofula is very readily developed in animals in whom the hereditary tuberculous diathesis obtains, provided there be no extensive deposition of tubercle. It can be brought about by the means already described, but every care has to be taken to avoid lympho-vascular inflammation. This is necessary, because the lymphatic system being already affected, any further weakening of the body is felt primarily by this system, and the tendency in all such cases is to the direct establishment of acute tuberculosis. When this last disease exists it is next to impossible to establish scrofula, unless the tubercular affection be first subdued. The means adopted for such establishment of scrofula increase the intensity of the tubercular disease, and death results long before that general bodily innutrition peculiar to scrofula can be brought about.

Question 13.—Is there lessened absorption in scrofula?—There is not any lessened absorption of non-fatty articles of diet. A scrofulous animal will consume non-fatty food, with a minimum of waste in the fæces; but fatty food is absorbed in small amount only.

Question 14.—To what is this due?—It would appear to be owing to insufficient secretion of the panereatie fluid and of bile. By establishing panereatic and biliary fistulæ in cats, as mentioned under tuberculosis, I have found these seeretions reduced, as in the disease last named.

Question 15.—Are the intestinal seerctions and contents acid in scrofula?—The secretions are not; neither in the herbivora have I found the contents so until the middle of the small intestine. In the omnivora the contents are distinetly aeid. This aeidity is, it would appear, due to the splitting up of the fatty portions of the food. It is increased by a fatty diet, and reduced to a minimum by one of a vegetable nature.

Question 16.—Must we, because of the preeeding facts, coneludc that scrofula ineludes tuberculosis?—No; true tuberculosis may be superadded to scrofula, but this is altogether exceptional.

Question 17.—What, then, are the pathologieal differences between tuberculosis and serofula?—Scrofula is a disease of nutrition; the tissues are ill-formed, and tend to break down under the slightest strain, but there is no single system affeeted, as a rule, more than the rest. The formation of tuberele is due to weakness of the lympho-vaseular systems, rendering them liable to give rise to inflammation under comparatively trivial exeiting eauses. This general malnutrition does sometimes affeet a partieular system or organ, and the eondition then is perpetuated in the individual, presumably by the law of cellular assimilation. When the lymphatie system is especially affeeted, true tubereulosis is the result.

Tubereulosis is not primarily a disease of general nutrition but of the absorbent or lymphatic system. It results in tuberele formation and impoverished blood, hence tending through inheritance to malnutrition and serofula; while scrofula through malnutrition tends to produee a weakened absorbent system, or tubereulosis.

Henee it is in old inherited eases, whether indueed in the laboratory or seen at the bedside, that tubereulosis and serofula are most generally seen in the same being. Eaeh tends to produce the other eondition. Serofula may be eonsidered as survival amid general unhealthy surroundings—as the result of proeesses whieh, had they been acted on by the ordinary causes of fatal disease, would have terminated the subjeet's life.

There ean be no doubt that if the ordinary eauses of death were less frequent in operation scrofula would inerease. Its ineipient subjects are mowed down by tens of thousands in our slums and

among the very poor in country districts. Scrofula is a modified physiological state; it is the result of the opposed action of agents tending to health and enfeeblement respectively; it is essentially a compromise between, and therefore a union of, these two. Its principle is best seen in the example of its production amongst peasantry breathing pure air, drinking pure water, and taking plenty of exercise, but miserably fed for the work they have to perform and the exposure they have to undergo.

Question 18.—What are the common causes of scrofula in the human subject?—It would appear to be the consequence of hereditary progressive atony. I have never seen scrofula result in the healthy child of healthy parents from its being subjected to unhealthy conditions of life. It is possible that it may thus be produced in the first generation, but such cases have not come within my range of research. States of life, all of which lead in one or more directions to enfeeblement, while in others they are healthy, and changing from time to time their particular enfeebling character, appear to be most favourable for the establishment of the disease.

The change mentioned is essential, for a continuance of unhealthy conditions identical in kind results always in one of two ways—(1) death, that is extermination, or (2) physiological accommodation.

Cases exhibiting scrofula-producing conditions might be adduced by the score. I will give here a few in whose accuracy I have every reason to believe:—

Case I.—R. T., aged twenty-four, costermonger. Scrofulous appearance. Born in Lambeth, and brought up in one of its slums; whole family of seven slept in one room. Has been from infancy subject to inflammation of lymphatic glands; in ninth year two glands in neck, and in eleventh year a gland in left axilla inflamed and suppurated. Parents alive; were immigrants from Ireland. Mother healthy. Father phthisical, skin affected with pityriasis simplex; was born in Cork; his father had been a merchant seaman, and had suffered from scurvy at sea three times.

Case II.—S. L., cabman, aged thirty-six. Very heavy and dull countenance. Scrofulous history from birth; abscesses in various parts of his body at different times; ankle joints swell after the least exertion in walking. Born in Staffordshire; parents peasants in that county; poorly fed, and often ill from want and exposure. Paternal grandfather had been a coal miner; suffered from phthisis; had given up mining and

settled on farm work; after this, disease made no progress and he married, his wife being the grandmother of the patient.

Case III.—G. T., ostler, aged forty-one. Full scrofulous diathesis. Born "somewhere in Islington." Father had been a public-house loafer, minding cabmen's horses, &c.; nearly lived on beer; had no recollection of his mother. Paternal grandfather had been a sweep; died of asthma.

Case IV.—N. A., gentleman, aged thirty-eight. Stunted and flabby appearance, but scrofula not well marked in conformation of features. Mother came of very healthy family. Father a beneficed clergyman, "delicate," hard student; health suffered in consequence, and had to give up work and retire to Continent, where N. A. was born. Paternal grandfather a gentleman farmer in Devon; very great eater; hard drinker; inclined to other excesses; has been described to his grandson as bloated and gouty.

Question 19.—Can scrofula be developed in utero as a result of temporary ill-health or nervous shock on the part of the mother, the progenitors being constitutionally healthy, and the surroundings conducive to bodily well-being?—Whether true scrofula may result from mere temporary innutrition of the healthy mother, and consequent innutrition of the fœtus, is an unsettled question. I cannot regard the evidence on this point which I have been able to collect as in any way conclusive. Still more unsatisfactory is that concerning the influence temporary innutrition of the father may have in the production of this state. The balance is certainly at the present moment in favour of the negative view, but more extended research in this particular direction may possibly alter the position of the scales. That such temporary innutrition will produce tuberculosis I have proved to my complete satisfaction, and this is what might be expected. Tuberculosis is the result of direct atony, and, as a consequence, any enfeeblement must very readily affect the lymphatic system; but scrofula is the result of enfeebling processes acting on the one hand, and nutritive processes on the other, the enfeebling being predominant and resulting in a physiological modification by which life can be maintained on a state of lowered nutrition of the whole body.

I have seen cases which leave no doubt in my mind that scrofula can result from nervous shock to the mother. There would appear to have been an arrested nutrition. All the children I have seen affected through this means have been stunted and ill-developed.

Nervous anxiety on the part of the mother will frequently produce tuberculosis in the child, but never scrofula. Hence the large

number of tuberculous cases seen amongst the illegitimate children of respectably brought-up girls.

In seeking for an explanation we must remember that brain-worry is blood exhaustion. That the maternal nervous system can, through its direct connexion with the nervous system of the child, control its nutrition is proved by the beneficial effects to the child in utero, resulting not merely from nerve-foods, when used by the mother, but also from the application of electricity; secondly, from the inheritance of psychoses, due to faulty nerve or brain nutrition; and lastly, from the effect on the child's body of strong maternal mental impressions, which cases, although they may excite the smile of flippant biological babes and sucklings, are too numerous and credibly witnessed to admit of the scientist's doubt.

Such an exhausted nervous influence, then, may in the cases of tuberculosis produced by nervous anxiety play an important part.

Question 20.—Is scrofula ever seen without some affection of the lymphatics?—The scrofulous condition, which is innutrition, of necessity includes innutrition of the lymphatic system, and consequent lymphatic weakness. The tendency to tuberculosis is therefore marked in all scrofulous subjects; but if exciting conditions be absent, actual formation of tubercle may never occur, while the diseases especially characteristic of scrofula may obtain in force.

The pathological relations of the scrofulous, tuberculous, and other conditions of malnutrition, absorption, and secretion, to each other, will now be generally considered.

Scrofula is the term applied to the condition of the body when the powers of general nutrition are deficient.

In tuberculosis absorption only is affected; in scrofula the absorbed material is not elaborated. The red blood-cells are immature, and the spleen is comparatively inactive. Scrofulous patients are not, as a rule, thin; the tissues, however, lack tone. Scrofula may be brought about by conditions lowering the nutritive qualities of the blood and the chemical constitution of the tissues.

A tubercular animal may become scrofulous. The conditions appear to be—such mode as does not afford opportunity for the development of tuberculosis, joined with a plenteous dietary, and an abnormal drain on the blood.

The proximate cause of scrofula is deficient nutrition. This may be expressed as a lowered vital tone of the whole of the tissues. The starting point may be—(1) exhaustion of nerve force

through elimination of elaborated nerve compounds and a consequent inability on the part of the nervous system to maintain its trophic influence; or (2) exhaustion of blood materials, by which the tissues are deprived of their proper food; or (3) blood starvation, resulting in the same manner as its exhaustion; or (4) the presence in the blood of improper, that is, poisonous materials.

The process of production of scrofula is that concerned in the causation of all disease, save accidental, zymotic, and congenital malformations; and even these three may result in the establishment of the same process. In order to fully grasp its nature, we must bear in mind the relations to each other borne by the body's various organs. The living animal body is a mechanism, and as such we must view it. The disease process may commence at any part of this mechanism. Selecting as the organ the most exposed to injury—the stomach—let this be injured, say, by alcohol, and digestion will become impaired. Impaired digestion means lessened nutrition of the blood. This last must find a result in poorer tissues. These tissues include all those entering into the structure of special organs. Then the nervous system will be weakened and its trophic influence lessened. The kidneys will be weakened, and poisonous material remain in the blood. So with the liver, while the lessened secretion of bile will still further impair digestion. So with the starting organ—the stomach. The blood now poisoned, offers not merely less nutritious, but poisonous food to all the tissues. And thus round and round in an ever-swifter circle the process sweeps on. But while this is continuing, extrinsic causes may be at work, and being brought to bear on a particular organ, may produce more intense disease, at the first purely localised. Thus exposure to cold may engorge the lungs—pneumonia. If a large extent of lung be affected and the tissues be feeble, death will generally result from the disease named. If the engorgement be more limited, and the tissues weak, secondary processes ensue, the result being phthisis. But should the engorgement be limited, and the tissues in a fairly tonic condition, resolution will ensue. So congestion of the kidneys following exposure to cold will terminate either in resolution or Bright's disease, according to the extent of the engorgement and condition of the parts.

By experiments on living animals I have found that when a thoroughly unhealthy state of the blood and tissues had been produced in any two, male and female, the young of these invariably exhibited a greater readiness to succumb to any noxious influences

brought to bear on them. Before experimenting on the offspring I never failed to detect in them impaired general vitality. In some cases there was found great localised debility, either in the kidneys, stomach, heart, or other important organs. And this local weakness readily caused its seat to be more markedly affected by debilitating treatment than other and more healthy organs.

The conditions necessary for the development of such general ill health have been already mentioned. The detection of the latter is not always an easy task where no organic disease exists; but where any doubt is felt, a just decision can be readily arrived at by killing the animal and examining the tissues of the body with the microscope. An autopsy at which all observations are made by the naked eye must by its very superficiality, and consequent unreliability, prove a failure. The microscope will very frequently reveal to the observer abnormal states of the cells, which *en masse* present nothing peculiar to the eye, and individually are undistinguishable by it. Local disease when produced I have not found to be inherited by the offspring of the animal under experiment; but I have invariably seen that the parts in the offspring corresponding to those affected in the parent, become more readily diseased than in the case of animals from parents not so affected. But, and this is of the utmost importance, if the offspring in question were particularly guarded against disorders of the parts concerned, they escaped; but their own families, on exposure to producing conditions, readily succumbed.

It is, then, to absence of such exciting causes in the human family that we must attribute the escape of children from the organic diseases affecting their parents, and to the recurrence of such causes that the descendants of the third and fourth generation suffer as did their progenitors.

The doctrine of the survival of the fittest is one demonstrable by experience. Such survival is due to gradual modification of the animal's constitution to agree with its surroundings.

But survival may not be identical with healthy vitality, and under certain conditions the resulting beings may be of an altogether low development. Further, it is the unfit who yield most readily to disease; and it is in these and their posterity that disease prevails. Even here, while the whole system of the descendant may be morbid—immensely more so than in the ancestor—it may not so readily become subject to acute affections under similar conditions as its ancestor. Thus, I have found,

apart from experimental research, that children and grandchildren of country persons, brought up in London slums, prove far more susceptible to fatal disease than those whose predecessors have for generations lived in those dens of filth. But in the latter there was an altogether lowered physique.

The doctrine of the survival of the fittest can be but rarely exemplified in the human family, in a natural manner, under the conditions of civilisation; for, by the continual inpouring of new blood, through marriage, every human being possesses in himself the constitutional tendencies of many divergent races of ancestors, and these conditions prevent both extermination and the thorough modification of the system. But the partial modification is to be found on every hand, and notably in those scrofulous patients who, save for the phenomena peculiar to their condition, fulfil all ordinary life-functions in a condition of health.

The Production and Relationship of Tuberculosis and Scrofula.

[= signifies *produces.*]

1. *Tuberculosis* has for cause—Weakness of lymphatics = { Non-absorption in intestines. Non-absorption of effete cellular matter. Lympho-vascular inflammation. }

Non-absorption in intestines = impoverishment of blood = Malnutrition.
" of effete cellular matters = Miliary tubercle.
Lympho-vascular inflammation = Caseous tubercle.

Malnutrition.	Stomach, &c.	=	Impaired digestion	=	Lessened absorption.
	†Kidneys,	=	Poisoned blood.		
	Liver, Pancreas, &c.	=	Impaired digestion	=	Lessened absorption.
	*Lymphatics	=	{ Lessened absorption. Lymphatic inflammation. }		
	Nervous system	=	Lessened trophic influence	=	{ Lessened nutrition. Absorption and excretion. }
	General tissues	=	General atony.		

* Lessened absorption in intestine = Impoverished blood = Malnutrition.
* Lessened absorption in tissues = Miliary tubercle.
* Lymphatic inflammation = Caseous tubercle.
† Poisoned blood = Malnutrition.

Completion of the Circle,

With special direction to disease of any particular organ, through exciting conditions.

* * * * * * * * *

2. *Scrofula* as above, commencing at Malnutrition.

The assertions made by certain eminent scientists that tuberculosis and pneumonia are due to certain lower definite forms of life—that is, are invariably of a specific septic character, has, I am sorry to say, met with a very general acquiescence without sufficient research or consideration.

That septic material taken from a tubercular subject and cultivated, may, by its injection into another animal's body, produce tuberculosis, proves nothing beyond the fact I have demonstrated, and apparently not grasped by the advocates of the specific septic character of tubercle, that any septic matters finding their way into the lymphatics will cause lymphatic inflammation, and, therefore, set up tuberculosis to a greater or lesser extent.

The asserted specific microbe of pneumonia has no more connection with this disease than any other form of life. Pneumonia can be produced, as shown already, by any of the septic forms, or by any other means of irritation.

A logical fallacy runs throughout the whole of the arguments of Koch and similar thinkers on this subject of septicism. It is assumed that because a particular thing can produce a disease, the disease is invariably caused by that thing; whereas, the conclusion can be relied on as accurate only when every attempt to produce the disease by other means has failed; and, since I have by experimental work proved that tuberculosis and pneumonia may be brought about by any irritant to the lymphatic system, the pseudo-microbes of tuberculosis and pneumonia resume their true position as merely accidental forms in a common state of septicism.

III.—THE THERAPEUTICS OF TUBERCULOSIS AND SCROFULA.

Of the so-called "systems of treatment" and "infallible specifics" for pulmonary phthisis that have, from time to time, occupied the attention of the profession, I have tested a large number in the laboratory and have found that those having any beneficial influence on the disease consist, in every case, of one or more means acting on one or more of the pathological processes involved, and never on the whole of such processes. Hence, while all such systems and remedies have proved efficacious in certain cases, in others they have totally failed to cure; this is due to the facts that the pathological processes of tuberculosis vary greatly in intensity in different subjects, that many of them obtain only at certain stages of the disease, and that when they obtain throughout, or in more than one stage, they do not exert an uniform influence during the whole period of their

subsistence. These considerations are applicable not merely to brutes but to the human subject. To instance their truth:[a]—Iodine has been lauded as a specific and failed; its action is that of an absorbent; at the commencement of tubercular disease, therefore, it is a rational medicine, but the later processes are but slightly affected by it. Tar water, another "specific," is a valuable antiseptic, and consequently of service when septicism obtains, but altogether useless under other conditions. Tartar emetic lessens the blood-supply to the lungs by depressing the circulation, but this vaunted curative agent is of service only when a pulmonary lesion has involved blood-vessels of size, giving rise to hæmoptysis. Salts, both phosphates and hypophosphites, cod-liver oil, and other nutritive medicines, while affording material for lung tissue, cicatricial growth, and nervous energy, are totally useless to suppress septicism, and any treatment of this kind becomes a battle between normal cellular growth and septic irritation, the tendency of the latter being towards suppuration.

The "antiseptic system" is really curative of one only of the pathological processes, and if the subject be not in the stage when this obtains, the phthisis will proceed unchecked. It is to be remembered that, although septicism nearly always occurs before death, it is not essential to a fatal result.

Electricity again, most valuable as a physiological stimulant, provides no food, and is not antiseptic.

These examples will show how partial and incomplete has been the treatment of tubercular consumption, for every agent mentioned has in turn served as a "specific."

Medical skill is nothing but the logical application of facts, and the difference between the oft-styled cleverness of one practitioner and the stupidity of another—for the laity express their minds pretty freely concerning the profession—is the exact equivalent of the difference in the logical accuracy with which the knowledge of the respective "doctors" has been applied.

Placing on one side those engaged in research and the practice of special departments of the profession, there is not nearly sufficient difference in the extent of the knowledge possessed by practitioners to account for the marked contrasts in the success of their several treatments. Not infrequently the balance of knowledge

[a] It is true that it possesses septicidal properties, but for these to exert any real influence in the later stages of pulmonary septicism it must be employed in quantities that are otherwise injurious.

between some two is so placed as to render the case apparently anachronistic—that is, the less learned practitioner is the more successful. I have known a medical student, whose acquaintance with materia medica, therapeutics, and medicine would certainly have failed to pass him at any examining board, treat severe and complicated diseases with far better results than the very men who were his teachers at the hospital. Moreover, his prescriptions were original. The whole explanation is—his mind was logical, and he applied logic to the facts set forth in his text-books.

In the cases of tuberculosis and scrofula we have, on the one hand, a series of connected pathological processes; and, on the other, a series of agencies by which these processes are capable of being controlled.

If, then, we understand the right relationship to each other of these pathological facts, and can determine when they obtain in the body, we should be able by the use of these agencies to bring about the physiological states constituting health.

This is not a mere logical theory, but a fact demonstrable both in the laboratory and at the bedside.

For the moment ignoring the facts these researches have revealed, and taking orthodox pathology and therapeutics as they were in 1864, 1874, or 1884, we are brought face to face with a sufficiency of information theoretically to yield results far more successful than those social and medical history would teach us have been obtained.

Whence, then, the failure?

Examine any leading orthodox work on medicine of the dates given and you will find therein valuable prescriptions and directions for treatment, but without accurate and definite instructions as to the particular pathological stages in which they will prove efficacious. Moreover, when the pathology is dealt with therapeutically, the advice given does not cover the whole of the bodily processes involved.

Very frequently the instructions grossly violate pathological indications. Thus it has been taught: "If the patient does not progress under the influence of iodine, try inhalations of tar." "Iron has, in some cases, proved beneficial." "As to climate, some do well in a dry, others in a moist atmosphere." "A case is reported in the *Lancet*, of such a date, in which great benefit was obtained from * * *." "Dr. So-and-so has had successful results with this or that," &c., &c., *ad nauseam*.

Here the treatment has been altogether worse than empirical, for

the knowledge of facts possessed has not been applied in a logical manner to the conditions to be remedied.

It is sufficiently distressing to find medical scientists attempting to remove one of many connected processes obtaining at the same time, and very often choosing the more proximate on which to operate, as if a successful result in the case of any one such process would of necessity produce a cure of the disease. But it is worse by far when we find that absorbents, antiseptics, tonics, and other descriptions of therapeutic means are tried one by one, as if their applicability to the condition of the patient could be tested only by experiment.

There is, perhaps, one thing yet more sickening, to which I will only allude—the flaccid helplessness of the teacher who looks from the patient to the cemetery gates and moans—We have no possible means of cure, and can, therefore, only endeavour to postpone the fatal issue by doing our best to support the strength and treating symptoms.

From the records of cases that have come into my hands I have found large numbers of patients to have undergone a treatment consisting of particulars altogether misplaced. Tar water, when there was no septicism; tartar emetic, when the blood pressure was low; iodine and sea air in the far advanced stage, when no amount of absorption could possibly effect a cure.

Every one of these agencies used in its proper place would have been of service, but, misplaced, the results have always been worse than *nil.*

It should ever be borne in mind that there is no chance work either in pathology or the therapeutical action of drugs of certain composition or nature. Differences in susceptibility exist—that is, dosology is not an exact science, but the action of every drug is constant for every human being, and, so far as research has extended, for every inferior mammal Thus, iodine is always an absorbent, and, although insusceptibility to its influence may be very marked, its action can be obtained by enlarged doses.

I might illustrate the historical treatment of phthisis by likening the disease to a hostile army occupying a conquered country, and the resources of medical science to the army of that country. What would be said of any general of the defensive forces who, instead of bringing all available means to bear on the foe where they would be most effective with the object of rendering the artillery power of the other useless, the cavalry powerless, and the infantry incapable of

maintaining their position—in short, by military skill and prowess overmastering his enemy—should try first his artillery, then, when it had failed to achieve aught, his cavalry, and next his infantry, and should use them, moreover, without regard for their fitness for the task assigned them!

Ridiculous as a cavalry charge against the walls of a fort may appear, it is not more absurd than the application of therapeutic agencies in the history of even recent medical science.

While the therapeutic battle has raged fiercely on the field of pulmonary phthisis, tabes mesenterica and tubercular meningitis have been comparatively free from warfare. In plain language, medical scientists appear to have agreed that aught approaching a cure in either disease was not to be looked for.

It may be admitted that while the pathology of tuberculosis was unknown, it was not in the power of medical men to effect the absolute removal of either condition; but, certainly, the logical application of known therapeutic agents would have relieved the diseases named of their severity, and prolonged life.

I am justified in coming to this conclusion by the results yielded by laboratory experiments on living animals, as well as by the effects produced in the human subject by therapeutic means used merely in accordance with the pathological knowledge of the past.

It having been seen that the pathological conditions in both diseases are incompatible with the due fulfilment of one or more of the body's functions, the first indication is the removal of these states for others approaching as nearly as may be to the normal.

There are certain first or general therapeutical principles applicable to the two diseases, and deducible directly from a knowledge of their pathology. The practicability of any measures based thereon is determinable only by the therapeutic means at command, and dependent, therefore, on experimental tests concerning the latter's value.

These principles are:—

1. Removal of constitutional condition by general measures.
2. Removal of local affections by general measures.
3. Removal of local affections by local measures.

It is evident that absorption secured in tuberculosis, and nutrition in scrofula, would, theoretically, result in the removal of the ensuing processes. But not only does direct action on the factor processes aid the result aimed at, but action at the primary source alone frequently fails, owing to fatal results being brought about

by the diseases before the measures adopted have had time to accomplish their intended work.

All vital action, whether physiological or pathological, is essentially nervous in character—that is, conducted through the nervous system. Hence all such action can be affected by operating on the nervous centres. A perfectly healthy nervous system must result in perfect health wherever that system extends.

But here, again, laboratory experiments teach us that valuable and important as such central action is, we cannot, owing to its slowness of operation, afford to rely on it alone, and dispense with more local remedies.

But medical science has seldom erred on this side. Indeed, one of the gravest charges that can be brought against therapeutists is that they have persistently refused to see the dependence local health had on that of the nervous system. The treatment of all disease has been, generally speaking, in my opinion, far too local in character.

It will have been seen that scrofula and tuberculosis are two conditions involving a series of identical processes, the individual factors, however, not coinciding each for each—scrofula commencing with malnutrition, and tuberculosis with impaired absorption.

Bearing in mind the further facts with which we have become acquainted, the physiological processes we have to seek to bring about are, therefore—

In tuberculosis—Absorption in intestines and tissues, prevention of congestion, nutrition, prevention and cure of septicism.

In scrofula—Nutrition, digestion, renal action, absorption.

Every one of these physiological processes is obtainable by the action, in each case, of a particular class of agents.

We know the nature of the disease. We know the bodily and other processes which will remove it. And lastly, we know the agents which will bring about each of these processes.

Our task is, therefore, merely to apply these agents rightly, and to do this we must understand in general:—

1. How these processes best affect the diseased system—singly or in combination.

2. The physiological channel by which each process is best affected—singly and in combination.

3. The known agents affecting each physiological channel.

4. The comparative efficacy of their single and combined action.

And we must understand in each particular case—

5 The pathological conditions obtaining.

Individual remedies may be found of far greater power than many of those I have employed, and which, on account of variation from the latter in their character, may necessitate other methods of application; but if my pathology be true, the therapeutical principles I have laid down are of necessity true also, and it is only in accordance with those principles that agencies of whatever nature can be efficaciously employed.

The space at my disposal is so limited that I purpose omitting the minute details recorded in my MS. notes, and giving only a summary of the results obtained and their consequent indications. I am the more free to do this, as the accuracy of the statements can be tested by any medical scientist.

The experiments in connection with the therapeutics of tuberculosis and scrofula were undertaken with the object of finding the effect on the diseases in their various stages of each of various classes of agents, and of the latter in various combinations. Theoretical considerations were entirely put on one side, and no conclusions formed until the termination of the various tests. The results obtained were, however, entirely in harmony with the indications to be derived from a logical consideration of known facts, pathological, physiological, and therapeutical.

It was never within my view to test the action of untried drugs. Rather was it my object to master the correct application of those known to us. It is but of scanty service to humanity to add to our list of resources when we have means at command whose power has been proven, but is misapplied through lack of method.

Again, while it has been sought to compare with each other in each of various classes of drugs the more important of their respective members, it was never for one moment designed to form anything like a complete list of remedies. The great end in view has been the proof by experiment as to the classes of agents that will bring about the desired physiological processes, and the modes of application by which this can be best effected.

It may be argued that analogy cannot be made to point from a known process or fact in a brute's body to a concluded like condi tion in the human subject. As all physiological and pathological knowledge is in favour of a true analogy holding, I might leave the oft-repeated falsehood to its fate; but I desire to point out that these researches deal, save incidentally, only with the brute creation, and I therefore urge hospital pathologists and physicians to test by all practical means at their disposal the extent to which the observations I have recorded hold good in the human subject.

The following table exhibits in, I trust, a lucid manner the scientific treatment of tuberculosis:—

Form of Disease	Physiological Process indicated	Channels by which Process may be brought about	Class of Agents by which effected
TUBERCULOSIS in all its forms	Absorption in tissues and intestines	Internal stimulation of lymphatics	Internal absorbents
		Local stimulation of lymphatics	External local absorbents Electric, thermal, frictional, and medicinal stimuli, exter.
		Internal stimulation of nervous centres	Internal stimulants and tonics
		Local stimulation of tissues	Electric, thermal, frictional, and medicinal stimuli, exter.
		Nutrition of nervous centres, organs, and parts	Foods, medicinal and dietetic
	Nutrition -	The processes bringing about absorption result in this	Do.
	Repression of septicism	Absorption and nutrition	As above
		Free antiseptics in blood	Medicinal antiseptics internally
		Antiseptic inhalation -	Atomised and vaporised antiseptics
PULMONARY TUBERCULOSIS only	Prevention of congestion	Free surface circulation	As for nutrition—external stimuli
		Nutrition	—
	Relief of concongestion	Relaxation of surface vessels	Rubefacient applications—med., thermal, and frictional
		Cardiac action - -	Stimuli, general and cardiac
		Contraction of vessel walls	Stimuli and tonics
	Arrest of hæmorrhage	Contraction of vessel mouths and coagulation of blood	Astringents internally and by inhalation
		Lessened cardiac action	Depressants
	Lessened expectoration when excessive	Nutrition - - -	Which see
		Contraction of vessels -	Astringents by inhalation
	Freeing mucus from bronchi	Increase in contractile power of bronchi	As for nutrition—stimulating medicinal expectorants, electric and frictional stimuli
	Freeing mucus from bronchi when latter are clogged and there is danger of collapse	Enlargement of calibre of bronchi by relaxation to permit passage of air behind clot, followed by	Laxative expectorants
		Increase in contractile power	As above

All the therapeutical experiments I have undertaken have, without exception, combined to lead me to the conclusion that the tuberculous condition is most rapidly removed when all the physiological processes negativing those of a pathological nature which obtain are set in action simultaneously—that is, the processes act best in combination. It is therefore necessary to combine only agents which do not exert on one another a neutralising action.

THE VALUE OF CERTAIN KNOWN AGENTS.

Class 1. *Absorbents.*—There are in the British Pharmacopœia only two drugs the preparations of which promote directly the process of absorption to any appreciable extent—Mercury and Iodine.

The most powerful preparation of mercury for inunction is the red iodide, next to this the green iodide, and third on the list may be placed the perchloride.

In all forms of tuberculosis where marked local symptoms are present, local inunction is of service. In general tuberculosis without local symptoms the seat of inunction should be the abdomen.

For fumigation the most powerful forms of the remedy are the metal and its two iodides. The subchloride is comparatively weak in action.

When taken by the mouth, the most powerful preparations of mercury are those advised for inunction.

The facility with which the drugs act on the system through the channels named is in the order—mouth, inunction, fumigation.

When these channels are combined the absorbent effect of the mercury is more readily obtained than by any one such channel alone. Nor is this due solely or mainly to the increased quantity of the material employed. For example, if three grains of the green iodide be taken internally as a daily dose for fourteen days, the beneficial effects will be far less than those resulting from the employment of the same quantity divided into equal parts for the three channels named, and this notwithstanding the inevitable loss resulting from inunction and fumigation.

Mercury used in this triple manner affects the whole absorbent system more rapidly than when applied through only one such channel, and salivation under careful treatment less frequently precedes the desired physiological results.

Considered at its best, it is, however, an undesirable medicine;

for, although in careful hands it may be made to do its duty without any evil after-effects, an error concerning constitutional susceptibility, or ignorance concerning a preceding mercurialisation, may be productive of much injury. I do not speak parenthetically; for, although my experiments have been conducted on brutes alone, it has been easy to ignore known peculiarities and previous treatment, and thus to bring the case to the level of those found in daily practice.

There is yet another channel by which mercury may be given—the lungs. Inhalation is, however, so rapidly productive of salivation and other dangerous conditions as to be altogether impracticable.

The second great absorbent—iodine—may, like mercury, be given by the mouth, inunction, fumigation, and inhalation. Internally, free iodine, its tincture, iodide of ammonium, and iodide of potassium, follow this order with regard to their readiness of action.

By inunction the same order is preserved—the crude iodine should be made into an ointment with lard without any other addition.

By fumigation—crude iodine, vapor iodi, iodide of ammonium, and iodide of potassium.

By inhalation—vapor iodi, and the iodides of potassium and ammonium; crude iodine is irritating when any pulmonary lesion exists.

In the case of any one of the above drugs its beneficial effects are increased by its employment through more than one channel. But this increase is yet greater when for each channel is used the particular preparation most suited for it.

Iodine is a far more valuable absorbent than mercury, but constitutional peculiarities with regard to its action are of very frequent occurrence both in the laboratory and at the bedside. These peculiarities generally take the form of increased susceptibility to its influence; deficient susceptibility is very rare.

When the tubercular diathesis obtains, but without marked local symptoms, the inunction should be performed over the abdomen. This, with the internal administration of the drug, should suffice so far as itself is concerned. Inhalation, when no pulmonary symptoms occur, is not advisable, as the lungs are very readily irritated by the iodine, and local effects in such cases certainly precede constitutional.

It must be remembered that the action of iodine is always absorbent. When not concerned in the removal of effete or deposited

material, its energies are expended in the absorption of the normal tissues.

It has been shown in a preceding article that it may be made to play an important part in the production of lymphatic exhaustion. This, however, is not so much the danger of its employment as an inhalant in general tuberculosis. That which results when no local tuberculous material is there for removal is the wasting of the lung tissue—pulmonary atrophy. The walls of the local vessels become weakened, and the local lymphatics enfeebled in their absorbent power.

When local tuberculosis obtains, the inunction should be effected over the region concerned. Fumigation may be practised under any form of the disorder, but inhalation is permissible in pulmonary phthisis alone.

Class 2. *Astringents.*—These are of service only in hæmorrhage and excessive expectoration. Internally there is but little choice between gallic acid, catechu, and krameria. These three are, in my laboratory experience, the best that can be employed. By inunction, gallic acid is to be preferred. Astringents cannot with success be applied by fumigation. By inhalation, however, they may be beneficially administered when pulmonary symptoms demand their employment, and then the spray will be found preferable to any other atmospheric means. No astringent with which I am acquainted has as powerful an action as iron. Either the perchloride or the sulphate may be used. The objection to its employment is its irritant character. Animals during its inhalation breathe very frequently with great difficulty and cough violently. This is more especially the case with the perchloride. It is necessary, therefore, to remove the spray the moment it is found the iron acts as an irritant. All powerful astringents when administered by the spray act best in tepid water.

Another powerful therapeutic agent is atomised ice water. The temperature of this may be graduated by having three or four vessels in use, and the addition to their contents of varying quantities of tepid or cold water. Atomised water just above the freezing point has in my hands arrested very severe pulmonary hæmorrhage without fail. The external application of cold to a vital part with the object of checking deeply-seated local bleeding is permissible only when other means have failed. It is one of the most dangerous agents we have at command, for the first effect, by checking the superficial circulation, is to engorge the more deeply-seated vessels,

and hence it frequently, in the laboratory, produces a fatal effect before any action on the bleeding vessels can result.

Class 3. *Medicinal Foods.*—These are amongst the most valuable in our store of resources. Although ordinary dietary contains everything that is required for the maintenance of health in debilitated states of the system, when absorption, digestion, and nutrition are, to a greater or lesser extent, impaired, common food is not in that form which will most readily become incorporated into the system, and it does not, like the articles of which I am about to speak, present another desideratum—the greatest potential nourishment in the smallest possible bulk. All these foods may be taken either by the mouth or rectum. The rectum, as the sole channel, is useful only when the stomach, on account of its irritability, rejects food entering it.

As an adjunctive channel, the rectum is of great service. A third channel is the skin, and this may be made to serve either by placing the subject in the bath or by inunction.

Medicinal foods are useful under every form and in every stage of tuberculosis, but more especially in the far advanced stage of pulmonary phthisis. Indeed when a pulmonary lesion has taken place they are second to none among essential therapeutic agents.

A food whose virtues are insufficiently appreciated is glycerine. It exists normally in the nervous system in combination with other compounds. It is the basic ingredient of fat. It is capable by modification within the body of forming and assisting to form other essential "proximate principles." That glycerine serves as a food in all these ways when taken in sufficient quantity is known to all physiologists.

The advantages of its administration is the labour thus saved to the system by the presentation to the tissues of an already elaborated material. Although an alcohol, it has no hardening effect on the nervous tisssues; neither does it in any way injure the liver, or lessen the oxidation of the blood.

The antiseptic properties of glycerine will be considered later on.

Fats and Oils.—The physiological uses of these in the animal economy are familiar to all medical scientists. In atonic states of the digestive system, however, fat as a dietetic article is in great part wasted. But scientific pharmacy has rendered this fact nugatory, for in emulsified and pancreatised fat we have a material requiring no digestion whatever. The highest praise is due to

scientific pharmacists for the preparations with which their skill has furnished the profession.

Cod-liver oil has been for many years called the sheet anchor of the physician in dealing with pulmonary phthisis. The metaphor may be completed by remarking that the anchor, though strong, has ever had such clumsily constructed flukes and fell on such a rocky ground that it had no hold, but let the poor ship Constitution be dashed hither and thither until it became a wreck.

It may be granted that unmedicated oil has this advantage over unmedicated fat—it does not need emulsifying. But saponification is an essential preliminary to its absorption. Hence, in atonic digestive states it effects but a minimum of good.

In pancreatised cod-liver oil we have, so far as can be, a perfect medicinal food, possessing all the nutritive potentialities of the oil, and requiring no digestion before its absorption.

All other dietetic articles can be given in a wholly or partly digested state, as the case may demand. Perfect predigestion of ordinary foods is not advisable save when the digestive system is much enfeebled, or when the food is particularly trying to the digestive organs, as is the case with oils, fats, and milk. I have found that a healthy animal maintained on predigested foods alone had its digestive powers impaired, and the evidence *post-mortem* would point as the reason the action the secreted, but physiologically inactive, because superfluous, fluids had upon the mucous membranes.

The salts of potash, soda, and lime are amongst the most important ingredients of the tissues, and their value as nutritive foods is deserving of the highest appreciation. Under whatever form these salts may be given, they undergo in the system decomposition, but this does not lessen their value.

The nutritive powers of these salts are influenced by the elements with which the base is combined. Of these phosphorus is deserving of special consideration.

It will be dealt with more fully further on. Here it may suffice to say that the hypophosphites are more stimulating than the phosphates. When preparations of free phosphorus are given with the object of promoting nervous action, the phosphates are to be preferred to the hypophosphites as medicinal foods, for the reason that the phosphorus in the latter is in a low state of oxidation, and any excess of the unoxidised material in the system is certain to be productive of injury, not benefit.

Iron, manganese, and ammonia are true foods, as they occur in the body, but in such small proportions to the mass of chemical constituents, especially in the first two cases, that any deficiency can be supplied in a few small medicinal doses. Anæmia, long supposed to be due to a deficiency of iron in the system, a pathological error, found its orthodox treatment in ferruginous medicines. Iron was poured into the body in the fervent hope that with energy and perseverance enough might be got together to supply the chemical deficiency.

Mineralised monuments of illogical superstition! An ocean to fill a thimble!

These drugs being assimilable only in very small quantities as foods, it is inadvisable to give them chemically compounded with other elements it may be desired to offer to the tissues. Thus the phosphate of iron passes in great part through the body, unaltered and unabsorbed.

Oxygen, however, a veritable food, can be given in the black oxide of manganese. The value of oxygen is partly as a food, partly as an antiseptic. When the lungs are healthy, a fully sufficient quantity of the gas is inhaled in any pure atmosphere for the body's well-being. When pulmonary lesions obtain, and the blood is imperfectly oxidised, oxygen inhalations will be found of service.

Internally, the manganese before mentioned and the permanganate of potash will readily yield the element. But the best compound with which I am familiar is the peroxide of hydrogen; it parts with its oxygen more readily than any other preparation. The whole of it is volatile, if rightly used; it contains the gas in a larger proportion than any other compound—16 of oxygen to 18 of water. That with which it is combined is water, and therefore inert. In using it we are practically dealing with the element alone in a liquid form; it can be given—in practice—to patients who would shudder at the idea of an inhaling apparatus.

Oxygen as a food is, in tuberculosis, of value only in the pulmonary form, and then only when there is extensive lung lesion, or other pathological conditions preventing the normal reception of the element into the blood.

Phosphorus.—This element is a normal constituent of the tissues, but not in the uncombined or free state. It exists in the body under the forms of free phosphoric acid and phosphates. Free phosphorus does not occur in any article of diet, and while, when taken medicinally, it becomes a food by combination internally with

other materials, it exerts special stimulant and tonic powers during the period of such elaboration. It is only in very minute quantities that phosphorus can be physiologically incorporated into the animal system. Doses of $\frac{1}{20}$ and $\frac{1}{30}$ grain given to cats and guinea-pigs, respectively, thrice daily for three weeks, I have found produce fatty degeneration of the liver and heart, and phosphorus was discharged, in various degrees of oxidation per anum. Now phosphoric acid (H_3PO_4) contains 31 parts of phosphorus in 98 of the acid, and, therefore 30 gr. measures of the acid contain, approximately, 9 gr. + $\frac{2}{49}$ of a gr. of phosphorus, and this quantity—that is, 30 gr. measures of the acid—I have given daily to cats, for periods of from one to five weeks, without producing any hurt whatever. In the form of phosphate and hypophosphite, as seen, this drug can be taken in large quantities with only beneficial results.

If we consider for one moment the amount by weight of the nervous tissue in an adult's body, and compare it with the minute doses of free phosphorus that can be given without poisonous symptoms occurring, we shall readily see, even dismissing from our minds the evidence I have brought forward, the utter absurdity of the hypothesis that the therapeutical effects resulting from the medicine are due to its serving as *food* for a tissue in which its weight of phosphorus is contained many thousands of times over. As food, indeed, its action could be no greater on the nervous tissues than a few grains weight of meat daily on the whole body of a starving navvy.

As a therapeutic agent, taken daily for weeks or months, phosphorus requires to be administered with care. When the bowels are constipated, or rendered so by medicinal means, there is danger of poisoning, for the unabsorbed residue of the drug—and there is nearly always some amount—accumulates in the intestine, undergoing imperfect oxidation, and then entering the system not infrequently produces injurious and even fatal results. That which I have allowed to result in my experimental work, for the purpose of testing the influence of the drug, shows a possible danger, and may be a fatal fact in the history, unrecorded, of everyday practice—unsuspected, and, therefore, thrice deadly. In all cases of phosphorus poisoning, I have found the first seat of pathological change to be the liver. Phosphorus is a stimulant and tonic, and its proper application will be spoken of when dealing with this class of medicine.

The Mineral Acids.—Hydrochloric, sulphuric, and phosphoric acid have a two-fold action as food. First, that which they exert in the

system when they have undergone absorption without change; and secondly, that which they effect in the intestines by their action on excreted and effete salts. These acids are not excreted in the free state but in combination, and chiefly by the urine.

Both in the blood and intestines they are conservators of energy by the chemical changes they effect in effete salts. Under their influence the body becomes better nourished, and the fæces poorer in their mineral constituents.

The proportionate quantity of the acid in each case absorbed unchanged, depends entirely on the presence or absence, and in the former case the nature, of material in the stomach and that portion of the intestines into which the acid may pass.

The presence of any combinable base or salt will cause a chemical reaction to occur, so that given before or after meals these acids, as such, do not undergo absorption.

Phosphoric acid in the free state occurs in the nervous centres, and the drug is therefore of value as a food. Also, by the conservative phosphates it assists to form, it is of service in furthering bone development in young children.

To sum up. While all the acids named are conservators of energy by renewing the activities of effete material, phosphoric acid is, in addition, a direct food for the nervous tissues. The pharmacopœial dose of this drug is altogether too small. I have frequently taken, when fatigued, three drachms in water, and have prescribed for brain-workers from one to two drachms, and never once with any injurious, but with, on the contrary, markedly beneficial, results.

But it must be understood that in none of these cases did any natural irritability of the bowels obtain. With a relaxed or irritable intestine, even a dose of thirty minims will produce diarrhœa. The common sense of a practitioner will dictate that he should satisfy himself as to the state of the bowels before prescribing the medicine, and to be certain of no injury arising through an error on this score he should give the drug in gradually increasing doses, commencing at, say, half a drachm.

With regard to brutes, the smallest dose I have (in experimenting on cats) found produce diarrhœa was twenty-six minims in three ounces of water. Some of the animals would take one drachm and a half without any subsequent morbid symptoms. When those who were affected by the minimal dose mentioned were subsequently made to swallow quantities varying from one to two drachms, the

only effects, both when the acid was given strong and diluted, were vomiting and increased diarrhœa.

Systemic poisoning by phosphoric acid is, in the laboratory at any rate, a physiological impossibility.

Class 4. *Stimulants and Tonics.*—Energy-producing drugs include all those whose administration calls forth increased activity on the part either of the whole body or of particular organs. This energy may be produced by :—

Food for nutrition, - - -	Medicinal foods.
Trophic influence promoters, -	True tonics.
Stimulators of activity, - -	Stimulants, or indirect tonics.
Conservators of energy, - -	Conservative tonics.
Regulators of organic functions, -	Regulating tonics.

There are drugs which act in some one only of these various ways; others exert their influence through two, or even the whole four of the methods indicated. In a very extended sense all such drugs are tonics; but the use of the term is inadvisable, as its inclusive character is apt to occasion misapprehension. Moreover, every drug, the taking of which results in improved health, is scientifically considered a tonic; but such general application of the term would result in its loss of all distinctive meaning, rendering it merely synonymous with medicine or physic.

The classification I have given, while aiming at scientific accuracy, will, I believe, be found suited for the exigencies of every-day practice.

Of medicinal foods I have already spoken.

The principal drugs that come under the heading of true tonics are—phosphorus, phosphoric acid, iron, silver, and zinc. All these, properly used, exert a general trophic influence; they restore the processes of nutrition in debilitated conditions, and the beneficial results they produce remain when their administration has been discontinued.

Phosphorus acts as a tonic to the whole body, by means of the raised trophic influence of the nervous system. But this latter is due not merely to increase of tone in the nervous centres, but also to their stimulation.

Stimulants comprise not only drugs acting on the whole system, but those which call forth temporarily the depressed power of certain organs in particular without first restoring their nutrition. Thus ether is a general stimulant, while taraxacum, nux vomica,

and gentian have respectively a hepatic, nervine, and gastric action. By the activity these local stimulants call forth they may lead secondarily to better nutrition of the whole body, including the organ primarily concerned.

Conservative tonics are of two kinds—those which act by preventing tissue waste, and those which render effete material capable of beneficial re-introduction into the system. Hence the second class of conservative tonics become medicinal foods.

Alcohol, tea, coffee, tobacco, and quinine lessen tissue waste by oxidation. The first three are in addition stimulants, increasing tissue change; while alcohol itself is in very small quantity a brain food. So that in estimating the value in the animal economy of these drugs, we must carefully consider the relative importance of—(1) the tissue saved, (2) the tissue destroyed, and, in the case of alcohol, the demand for this componnd in the nervous system. These points have to be determined in each case by the peculiar physiological conditions concerned, and which depend on the age, occupation, and health of the individual.

Again, bromine acts as a conservative tonic of the first class by diminishing brain wear. As examples of the second class of conservative tonics may be mentioned the mineral acids.

Regulating tonics are drugs which do not act primarily by improving cellular structure, but which by their influence—stimulant or depressant—on the functions of localised whole organs, bring these to the normal, and hence improve secondarily the body's tone, and ultimately, through regulated action, the nutrition of the organ itself.

Conservation of energy by inhibition of oxidation, although temporarily conducive to a general sense of well-being, is ultimately injurious by preventing the excretion of effete material. Hence, as tonics, quinine, and other drugs of the same class are of true service only when the system is so enfeebled that, cellular recuperation being performed with difficulty, it becomes an object to keep the tissues as much *in statu quo* as possible. All the experiments I have performed show that quinine used under other conditions is absolutely hurtful.

Now in laboratory practice with dogs, cats, guinea-pigs, and rabbits, there is not a single stage of tuberculosis, under any of its forms, wherein quinine exerts any beneficial influence. On the contrary, its action is injurious throughout the disease, and in some stages hastens the progress of the malady to a fatal end. It is in

pulmonary tuberculosis that the deleterious influence of the drug is most apparent. The very presence of tubercle in the lung diminishes the oxidation of the blood. And this lessening becomes more and more marked as the lesions spread. If quinine be given when this form of tuberculosis obtains, and more especially in the advanced stages, the blood may be so imperfectly oxidised as to occasion death from dyspnœa. From the cases I have had under experiment, I find that of the two classes—the one treated with quinine, the other left wholly to the operation of the processes at work—those treated with quinine arrived the sooner at a fatal termination.

Alcohol would be as objectionable as quinine; but besides its conservative action by lessening oxidation, it is as noted a food and a stimulant. Moreover, if given freely, it runs in the blood for some time unaltered, and thus has an antiseptic action at the seat of any lesion.

As the object of the physician in dealing with tuberculosis is to call forth or stimulate the energy of the living bodily machine that it may incorporate into its substance the medicinal and dietetic foods given, and so gain real strength, as well as to endeavour to attack more directly the abnormal conditions of local regions—alcohol being a nerve food and stimulant, is valuable. Certainly the beneficial effects resulting from its use more than counterbalance the mischief which is the inevitable sequence of lessened oxidation. Moreover, we can give oxygen medicinally as a gas, or in combination as a drug, and the result is to altogether negative the inhibitory effect of the alcohol. I have employed the drug in the laboratory throughout tuberculosis in its various stages and forms, and I have found it of value chiefly in two ways—first, in commencing medical treatment, by its stimulant action on the nervous system, and hence on the absorbents; and next, as an antiseptic in the advanced stage of pulmonary disease. When the system has been stimulated and medicinal foods are being readily absorbed and incorporated, I have not found any marked advantage to result from its employment. Under its influence the animal and saline matters in the urine were invariably increased, due probably to stimulated expenditure of force and destruction of tissue; and although larger quantities of the phosphates and other such foods were absorbed than without the use of the drug, there were no signs of corresponding physiological benefit. Increased supply and increased expenditure left no apparent difference

in the balance. In the human subject, however, the value of alcohol is partly in its subjective effect; and therefore when the sense of health is increased by its use it may well be employed, even although we know that chemical or structural benefits are not to be looked for.

Free Phosphorus.—As a stimulant I have found this drug of service when commencing treatment, and in dealing with phthisis purposely neglected until the advanced stages were reached. Throughout the latter it can be given with advantage; but its constant use from the commencement is not attended with desirable results. In the first place, it does not supply the material for the energy it discharges. Then, even in small doses, long taken it causes fatty infiltration of the liver. And lastly, it is to a limited extent a cumulative medicine apt to give rise to symptoms of acute poisoning.

Phosphorus in itself is not poisonous; its fatal powers, like its therapeutic, are due to the compounds it so rapidly forms.

Phosphoric Acid and the other mineral acids may be used in combination as conservative tonics throughout the disease.

Nux vomica and other local stimulants are valuable at the commencement of treatment. I have, however, never found benefit to result from their continued employment.

Class 5. *Antiseptics and Septicides.*—The processes involved in protecting a tissue against the action of living forms, and in the destruction of these forms, are essentially distinct in their character. This has only very lately been recognised; and whereas formerly all drugs inimical to the development in the body of septics were without discrimination styled *anti*septics, pathologists now very generally distinguish them into two classes: those protecting the tissues—to which the old name is applied; and those destroying the forms of life—disinfectants.

I accept the two terms as scientific, but each is capable, I submit, of accurate subdivision as follows:—

Tissue protectives—Antiseptics,	- -	{ Common. / Specific.
Septicides or disinfectants,	- - -	{ Common. / Specific.

The blood is naturally antiseptic.

From an extensive series of experiments, the results of which I purpose giving to the world under the title of "Specific and Common Septicism," I have found that living forms never multiply

in the vascular system; that when they exist therein their seat of propagation is either a lesioned tissue, or the effete and excreted matters to be found in the respiratory and digestive tracts, as well as on the body surface.

Drugs having a definite action on one or more of the specific forms invariably act protectively or destructively, as the case may be, against the common forms. But the converse is not the case.

The following table is intended to show the method of application I have found most efficacious in the case of the chief septicides and antiseptics. One or two of these have a lethal action on certain specific febrile "forms":—

Antiseptics:	for internal employment	Glycerine. Alcohol.

Septicides or Disinfectants.	For internal employment	Peroxide of Hydrogen. Permanganate of Potassium. Carbolic Acid.	
	For inhalation	Creasote. Peroxide of Hydrogen. Permanganate of Potassium. Sulphurous Acid.	
		Corrosive Sublimate Amyl Alcohol	Only when septic processes have been subdued. To prevent germination.
	For inunction	The employment of septicides in this manner is altogether needless.	

Exercise, *Climate*, *Massage*, *&c.*, are therapeutic agents obviously beyond the sphere of the experimentalist's range of research.

As to climate, the thermal and atmospheric conditions employed by the worker must, either in their production or attending circumstances, be more or less artificial and unnatural; and results obtained are not at all reliable. These matters are for the decision of the clinical observer.

Electricity.—My own experiments with this agent so closely agree in their results with the observations recorded by medical scientists, whose studies have been made at the bedside, that I have little to add to our stock of facts concerning it. The continuous current is of value throughout the disease. It improves *all* the physiological functions, and must be held to occupy one of the highest places in the list of agents. The interrupted current I have found of service chiefly in the pulmonary form of tuberculosis, and then to bring about removal of impacted matters. Its application should be preceded by warm inhalations—medicated or not as the severity of the case may indicate—or by laxative expectorant

drugs. By this means the bronchi become relaxed, air passes below the impacted mass, and the subsequent contraction of the bronchial walls results in the expulsion of the impaction.

Scrofula.—The pathology of scrofula has been already described. We have seen that the processes involved in this condition and in tuberculosis are identical, but that the two diseases commence at different points in the circle of causation. The therapeutic agents which control tuberculosis exert an equal influence on scrofula. All that has to be done in commencing treatment is to diagnose accurately the conditions obtaining, and to apply to these the already proved remedies. Separate details concerning the therapeutics of scrofula are not therefore required, and would necessitate a repetition of facts already stated.

As these papers, like the experiments with which they deal, have been severely practical, I purpose leaving the stated facts to the judgment of science without further argument.

But I cannot lay aside my pen without warmly thanking those many illustrious and exalted scientists whose friendly criticisms and kind commendations have encouraged me to further exertions.

My last wish in committing this reprint to the world's care is not that it may be a "success," but that what of truth it contains may be established, what of error forgotten.